

**DESCRIPTIONS OF ANALYTICAL RELATIONSHIPS
FOR EVALUATING
CHINOOK SALMON ASSESSMENT VARIABLES**

Resource Category: Fisheries

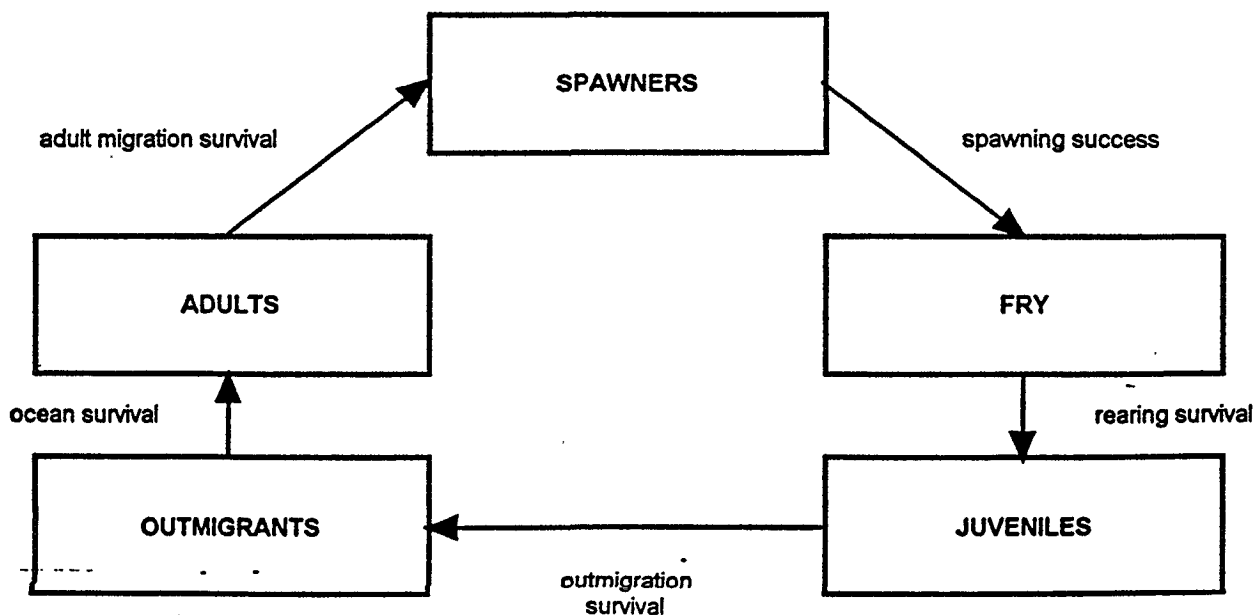
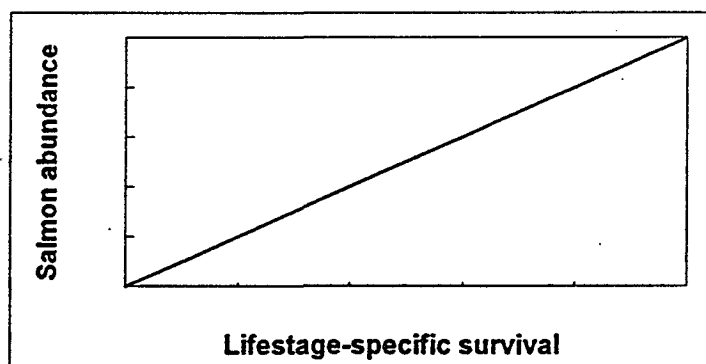
Relationship: Winter-run chinook salmon abundance vs. Lifestage-specific survival rates

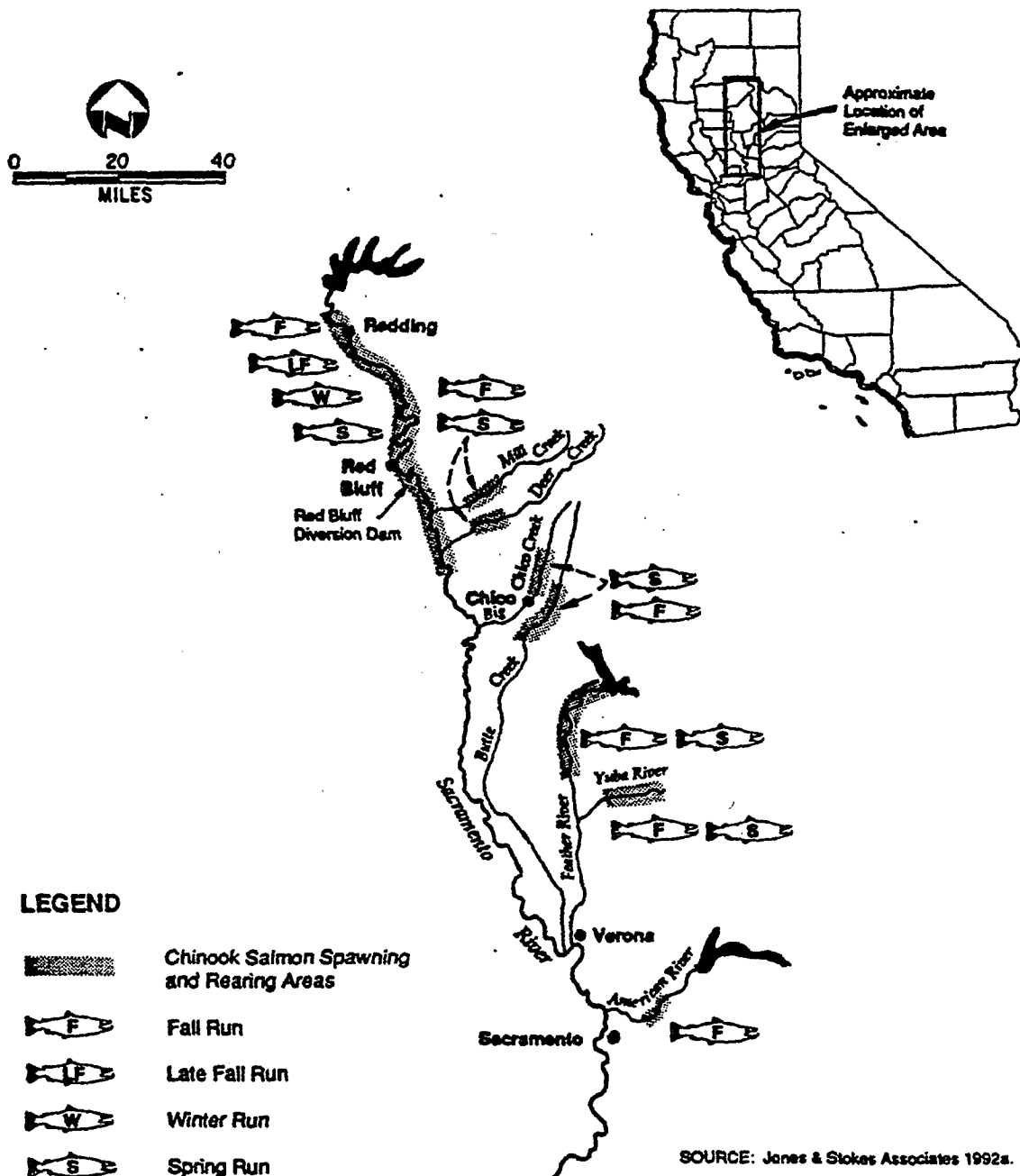
Description: The abundance of winter-run chinook will increase linearly with an increase in a lifestage-specific survival rate.

Assumptions: For a change in lifestage-specific survival rate to have this effect, the assumption is made that all other lifestage-specific rates remain the same. These rates are assumed to be independent, i.e. habitat changes which increase, say, spawning success do not affect rearing survival.

Basis: Theoretical. Very little data exist to determine lifestage-specific mortality rates.

Reference:



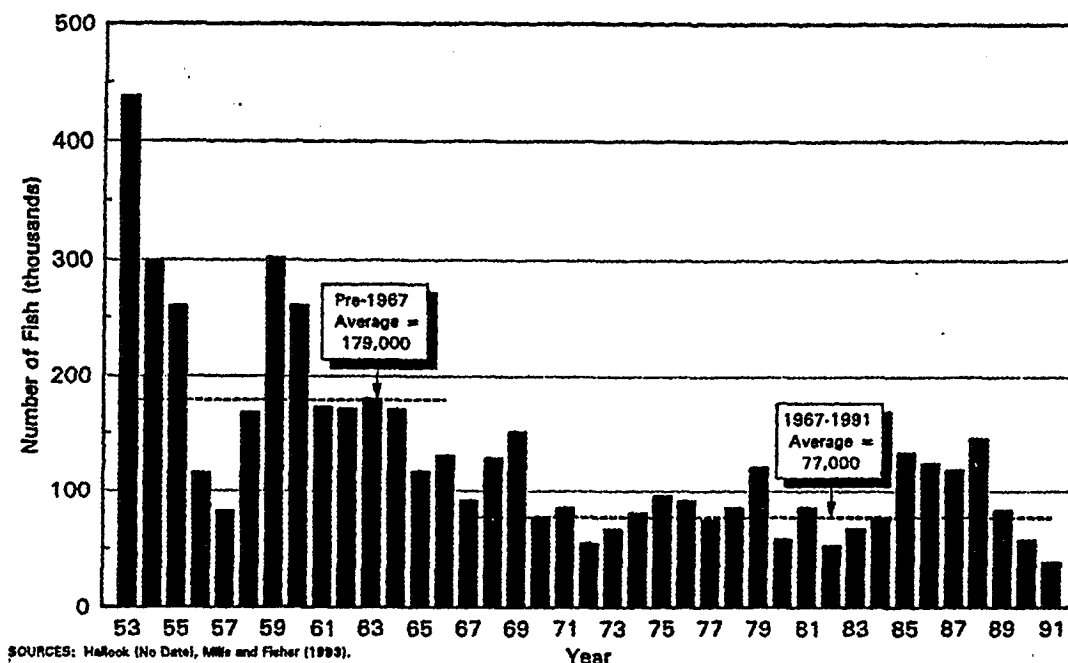


MAJOR CHINOOK SALMON SPAWNING AND REARING AREAS IN THE SACRAMENTO RIVER BASIN

Resource Category: Fisheries - fall run chinook salmon

Relationship: Run-size estimates of Sacramento fall-run chinook salmon from 1967 to 1991.

Reference: U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.

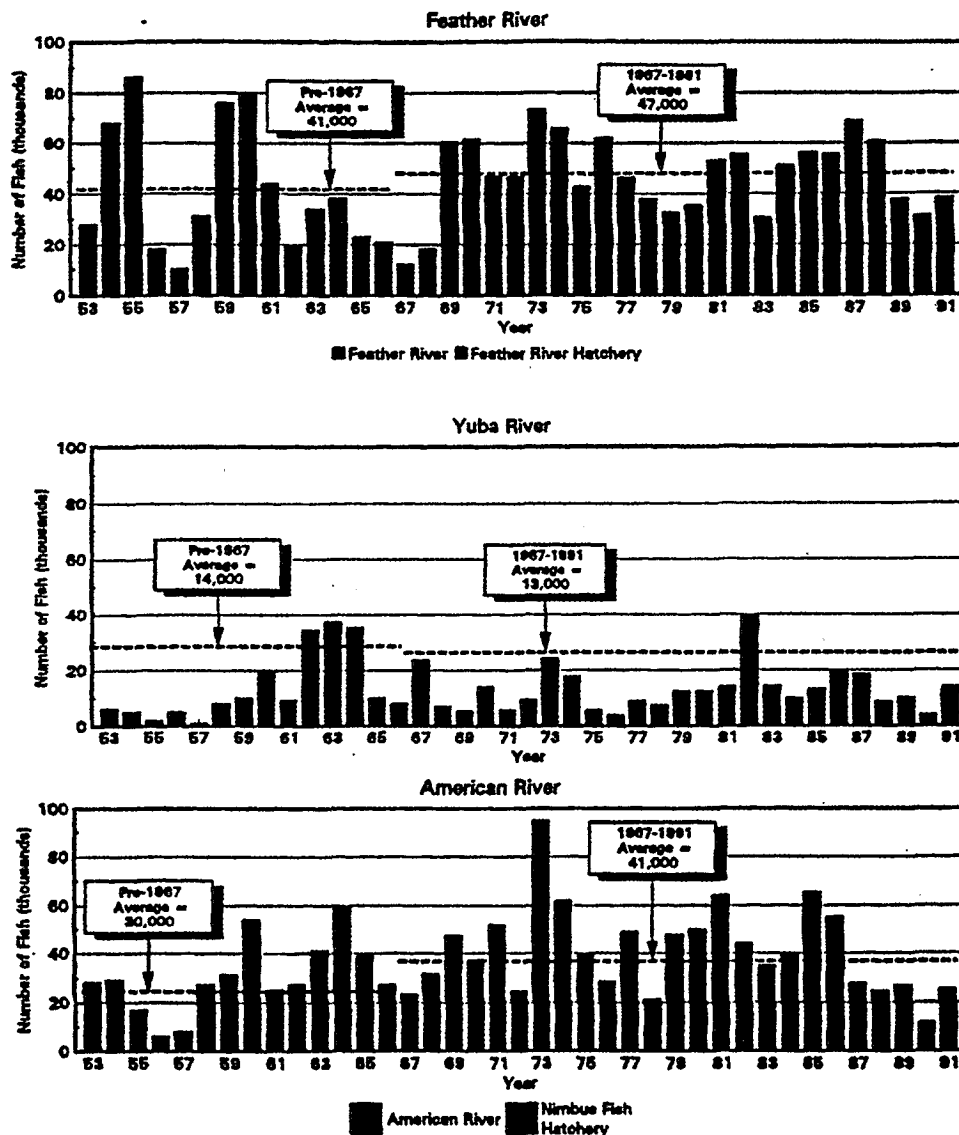


**ANNUAL ESTIMATES OF FALL-RUN CHINOOK SALMON SPAWNING ESCAPEMENT
IN THE MAINSTEM SACRAMENTO RIVER (1953-1991)**

Resource Category: Fisheries - fall run chinook salmon

Relationship: Run-size estimates of Feather, Yuba, and American river fall-run chinook salmon from 1967 to 1991.

Reference: U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.



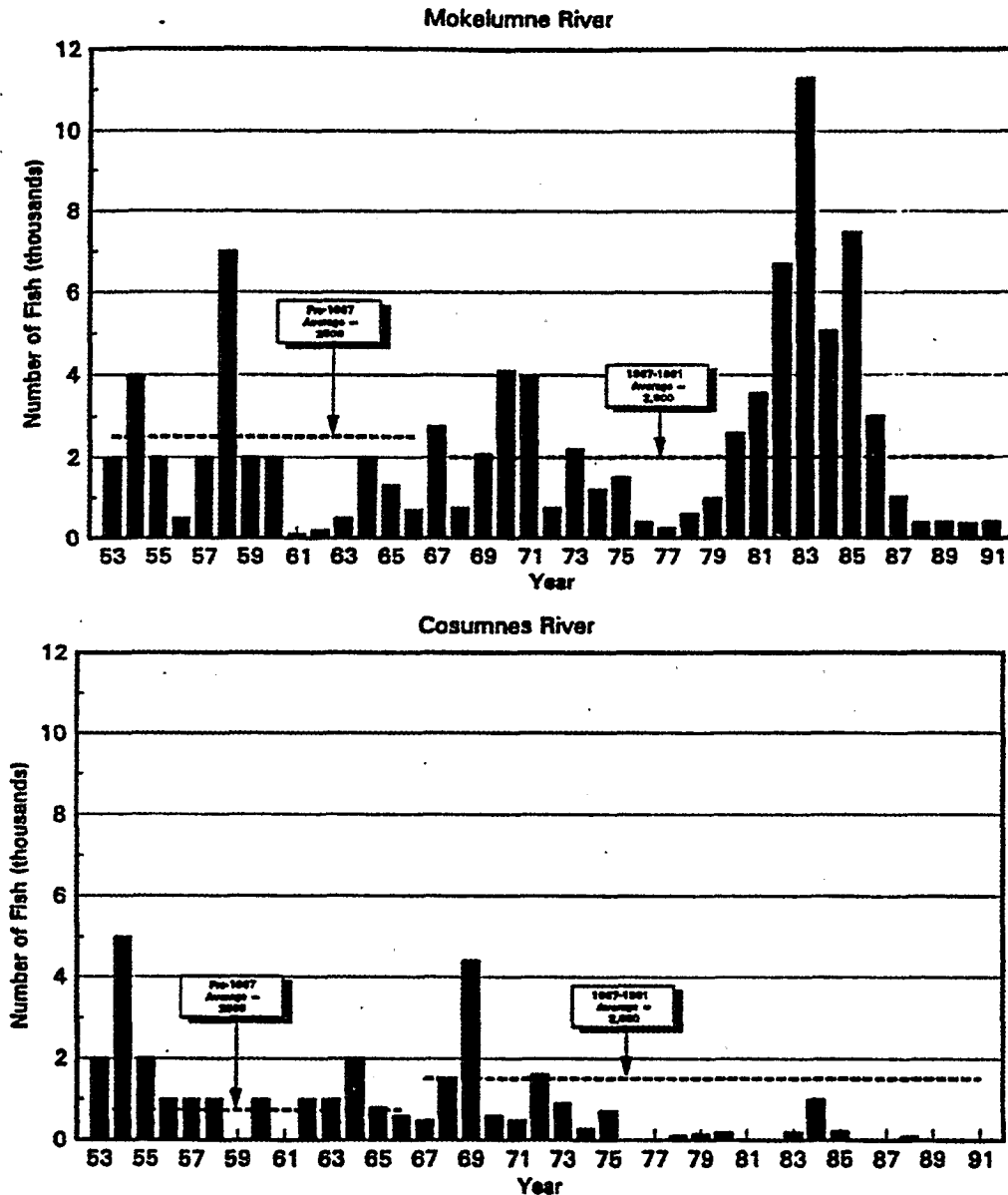
SOURCES: Hellock (No Date), Mills and Fisher (1983).

ANNUAL ESTIMATES OF FALL-RUN CHINOOK SALMON SPAWNING ESCAPEMENT IN THE FEATHER, YUBA, AND AMERICAN RIVERS (1953-1991)

Resource Category: Fisheries - fall run chinook salmon

Relationship: Run-size estimates of Mokelumne and Cosumnes rivers fall-run chinook salmon from 1967 to 1991.

Reference: U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.



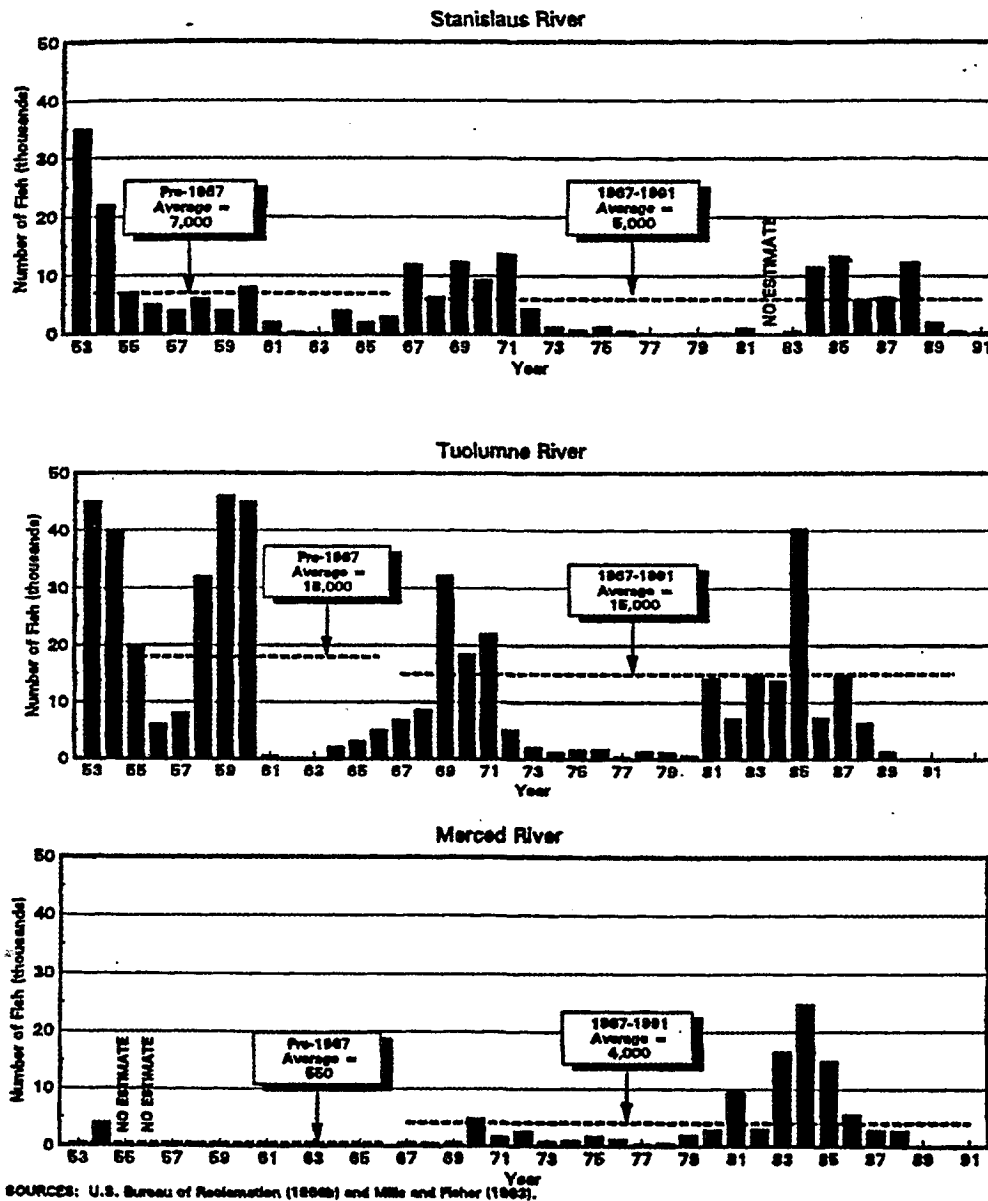
SOURCE: U.S. Bureau of Reclamation (1986) and Mills and Piner (1993).

**ANNUAL ESTIMATES OF FALL-RUN CHINOOK SALMON
SPAWNING ESCAPEMENT IN THE MOKELUMNE AND
COSUMNES RIVERS (1953-1991)**

Resource Category: Fisheries - fall run chinook salmon

Relationship: Run-size estimates of San Joaquin fall-run chinook salmon from 1967 to 1991.

Reference: U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.



SOURCES: U.S. Bureau of Reclamation (1968b) and Mills and Pipher (1983).

**ANNUAL ESTIMATES OF FALL-RUN CHINOOK SALMON
SPAWNING ESCAPEMENT IN THE STANISLAUS,
TUOLUMNE, AND MERCED RIVERS**

Resource Category: Fisheries - winter-run chinook salmon

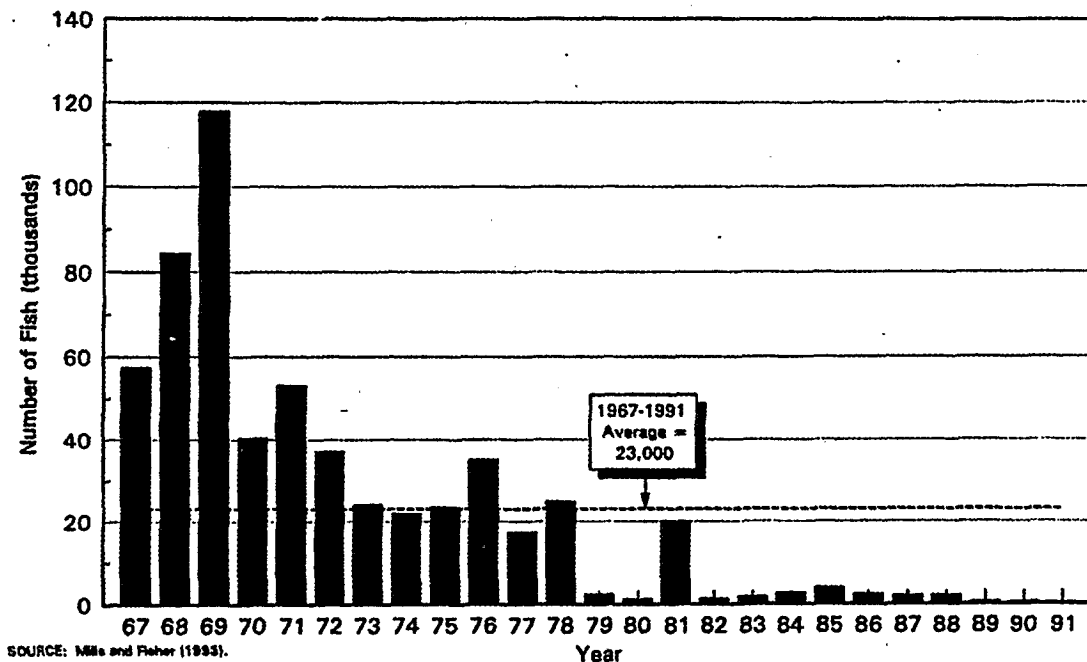
Relationship: Run-size estimates of Sacramento winter-run chinook salmon from 1967 to 1991.

Description: Annual run-size estimates for period.

Assumptions: NA

Basis: NA.

Reference: U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.



**ANNUAL ESTIMATES OF WINTER-RUN CHINOOK SALMON SPAWNING ESCAPEMENT
IN THE MAINSTEM SACRAMENTO RIVER (1967-1991)**

Resource Category: Fisheries - Fall-Run Chinook Salmon

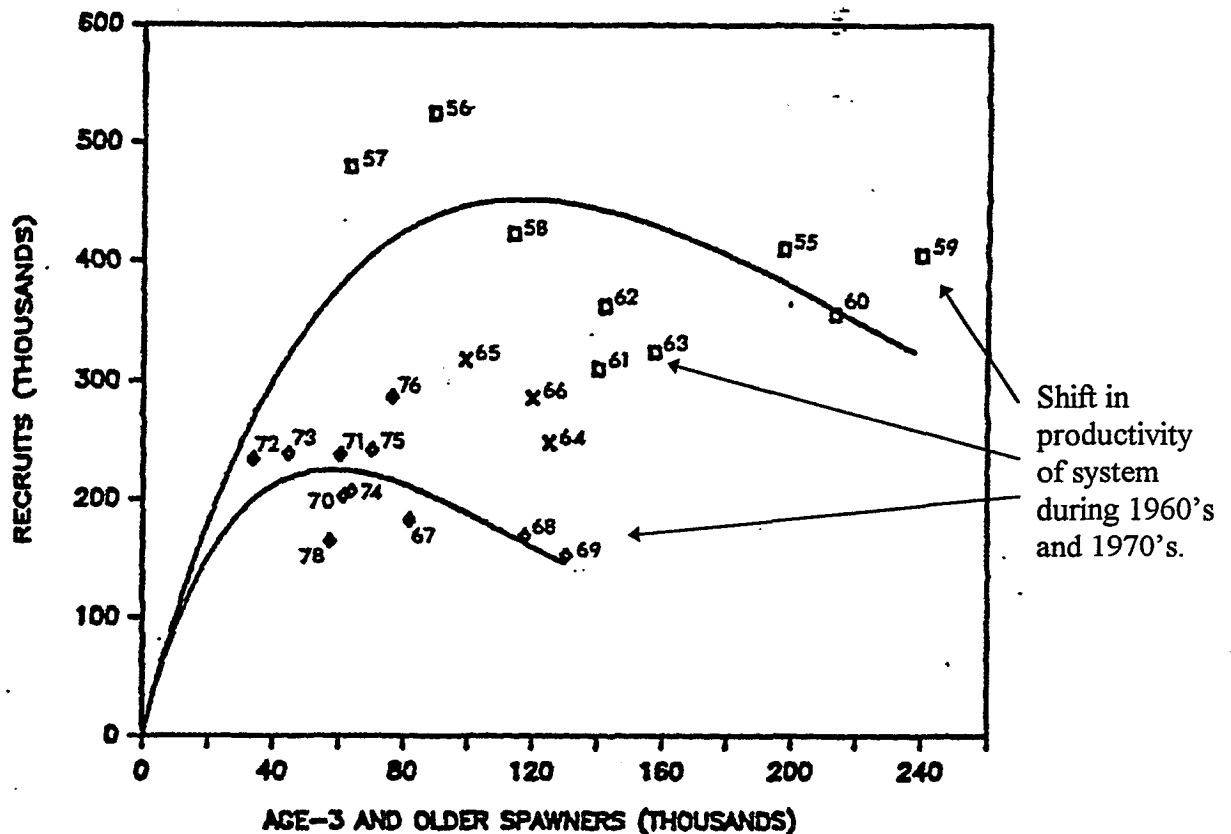
Relationship: Spawner - Recruit

Description: Production of chinook salmon as related to unit of parental stock varies with environmental conditions.

Assumptions: Ricker stock-recruitment relationship that is density dependent.

Basis: Escapement estimates of fall chinook salmon in upper Sacramento River.

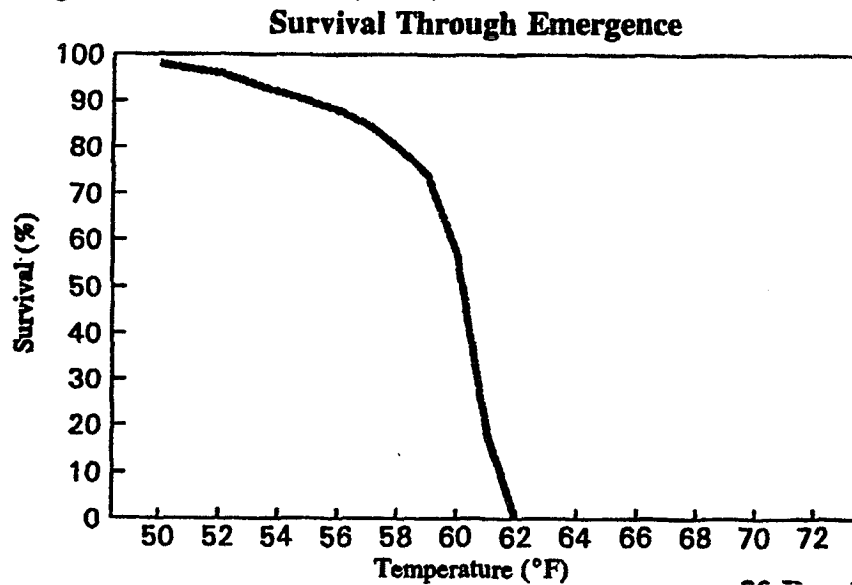
Reference: Reisenbichler, R. R. 1986. Use of spawner-recruit relations to evaluate the effect of degraded environment and increased fishing on the abundance of fall-run chinook salmon. *Oncorhynchus tshawytscha*. in several California streams. Ph.D. dissertation. University of Washington. Seattle, WA. 175 p.



Category: Chinook salmon.

Relationship: Salmon early survival through emergence as a function of water temperature.

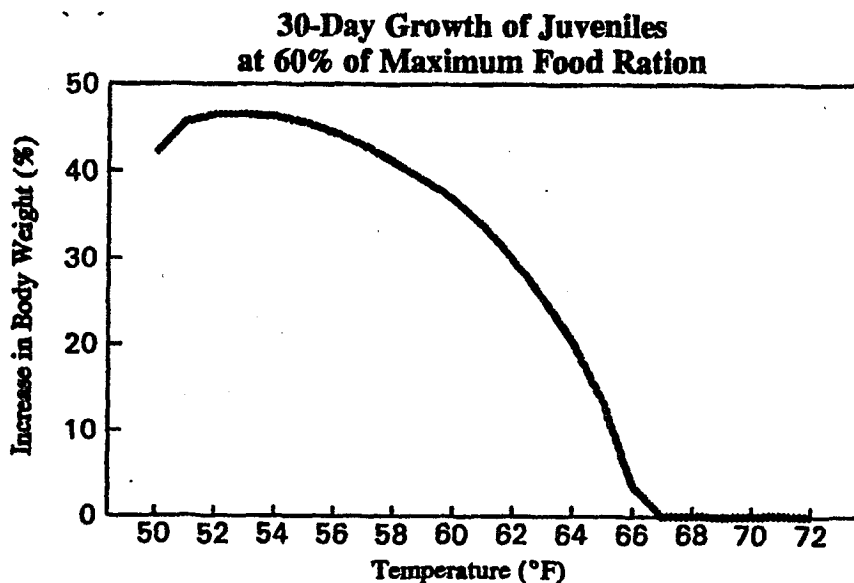
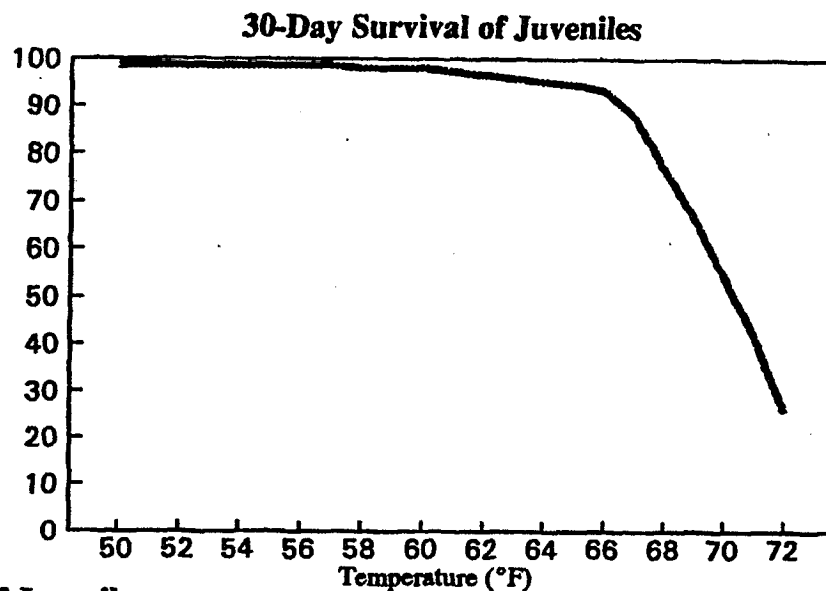
Reference: Brett, J. R., W. C. Clarke, and J. E. Shelbourn. 1982. Experiments on thermal requirements for growth and food conversion efficiency of juvenile salmon *Oncorhynchus tshawytscha*. (Canadian Technical Report of Fisheries and Aquatic Sciences No. 1027.) Department of Fisheries and Ocean, Fisheries Research Branch, Pacific Biological Station. Nanaimo, B.C., Canada.



Category: Chinook salmon

Relationship: Early survival of juvenile chinook salmon as a function of water temperature.

Reference: Raleigh, R. F., W. J. Miller, and P. C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: chinook salmon. (Biological Report 82 (10.122) September 1986.) U.S. Fish and Wildlife Service. Washington DC.



Resource Category: Fisheries

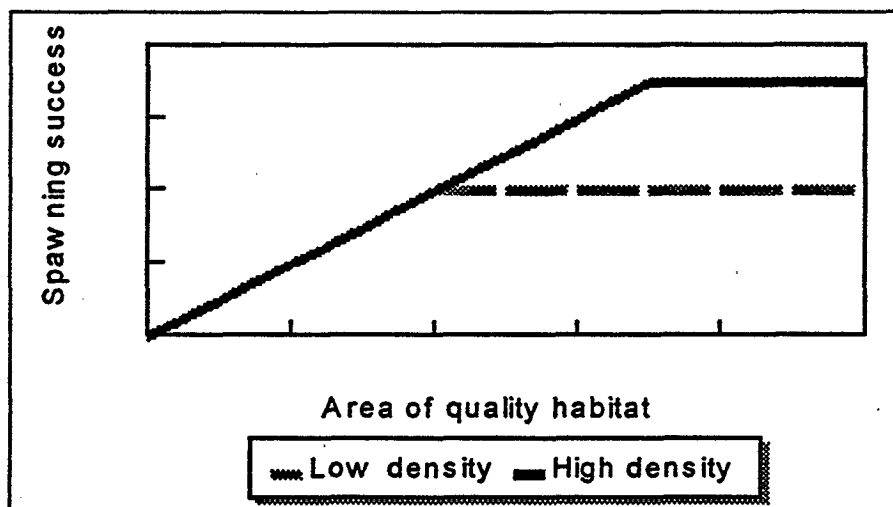
Relationship: Winter-run chinook salmon spawning success vs. Area of quality habitat

Description: Chinook spawning success will increase linearly as the area of suitable habitat increases. This linear increase will continue until all spawning fish are in suitable habitat, when the relationship will level off. The amount of habitat at which survival effects are no longer evident will vary annually depending on fish density. An optimal amount of habitat could be defined given expected numbers of spawning adults at a desired winter-run population level. The exact nature of the relationship will vary among rivers.

Assumptions: This relationship assumes that spawning habitat is limiting.

Basis: Theoretical. Very little data exist to determine the exact nature of this relationship.

Reference:



Relationship and Category: Salmon habitat - River flow Fisheries

Description: The amount of habitat available for various activities and lifestages of chinook salmon (e.g. juvenile rearing, adult spawning) is directly related to flow levels in rivers. The Instream Flow Incremental Methodology is the most common method of conducting this type of analysis; the quality of habitat for salmon is usually measured in terms of velocity, depth and substrate (sometimes cover), and expressed in terms of Weighted Usable Area (WUA).

Assumptions: Suitable physical habitat conditions are accurately identified for fish species/lifestage. Weighted Usable Area (WUA) is a reliable index of available fish habitat and accurately reflects conditions for fish.

Basis: Several instream flow studies have been conducted throughout the Sacramento-San Joaquin basin, but few have attempted to validate the basic assumptions of the models.

Reference: Bovee, K.D. 1982. A guide to stream habitat analysis using the instream flow incremental methodology. U.S.F.W.S. Biological Services Program FWS/OBS-82/26.

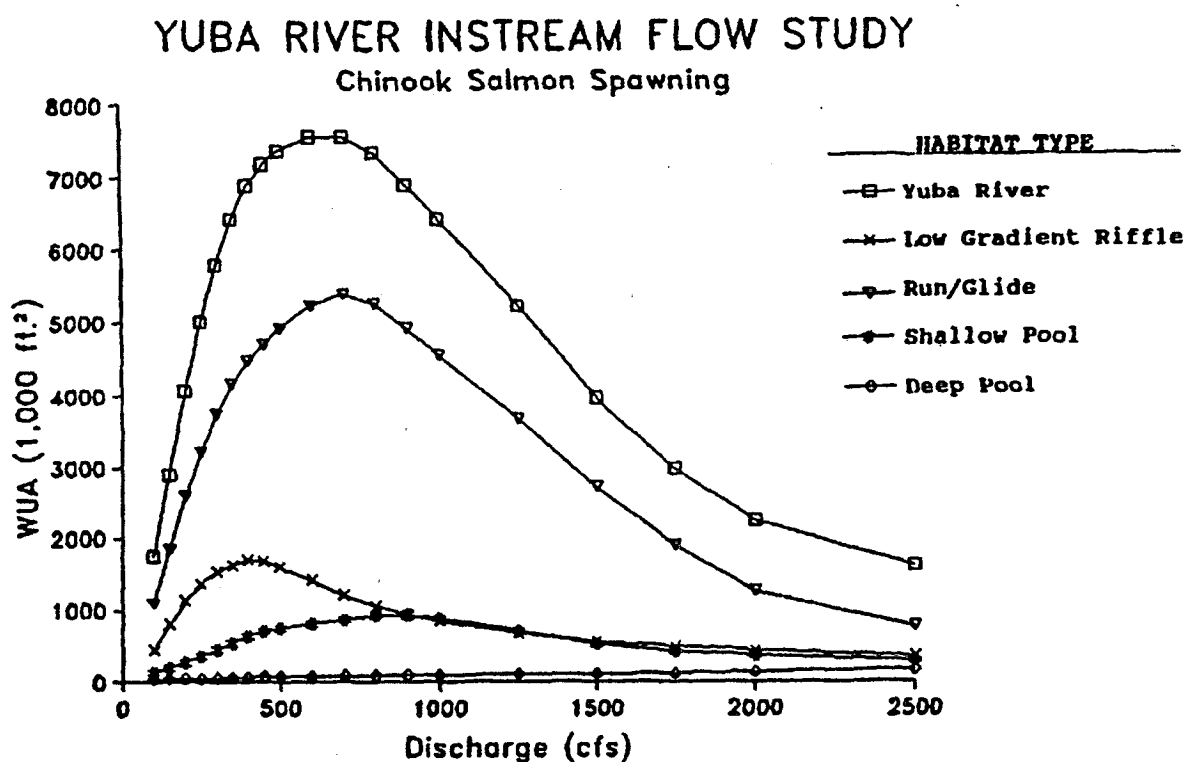


Figure 8. Chinook salmon spawning total weighted usable area (in 1,000 sq ft) by discharge for the Yuba River study area and by habitat type.

Resource Category: Fisheries - spring-run chinook salmon

Relationship: Habitat suitability as a function of flow.

Reference: BioSystems Analysis, Inc. 1989. Chinook salmon population model for the Sacramento River Basin - Version CPOP-2. Submitted to California Department of Fish and Game, Sacramento, California.

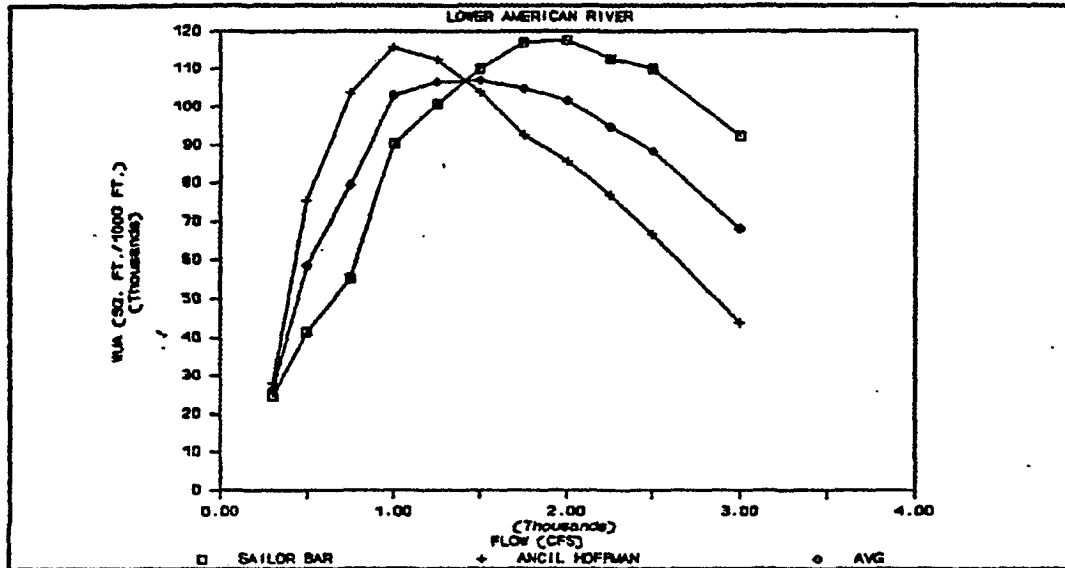


Figure 15. Relationships between flow and spawning habitat in Lower American River (from USFWS 1985).

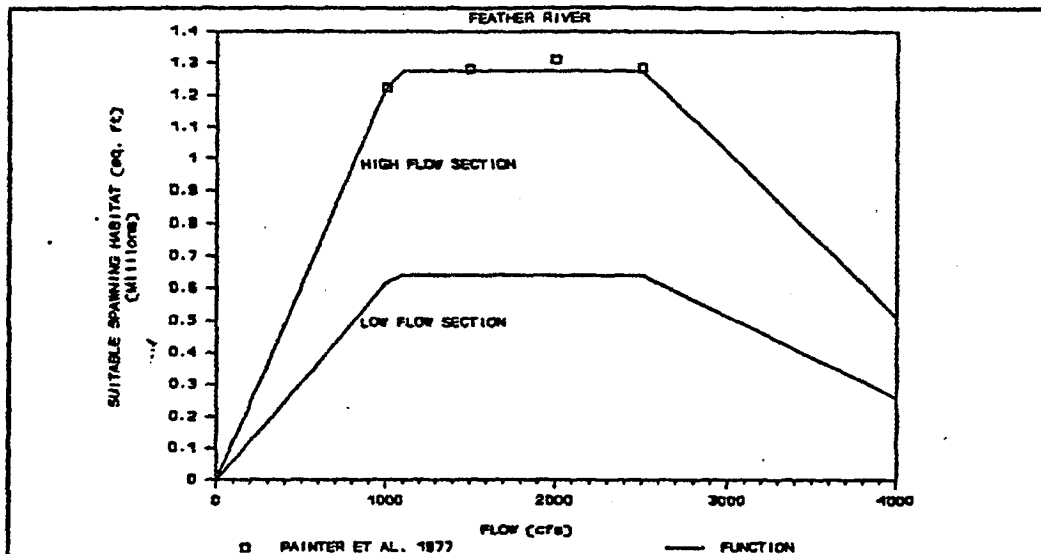


Figure 19. Flow component of inter-gravel mortality.

Category: Fisheries - Sacramento River chinook salmon

Relationship: The survival of juvenile chinook salmon is directly related to flow levels in the Sacramento River.

Reference: Kjelson, M. A., P. F. Raquel, and F. W. Fisher. 1981. Influences of freshwater inflow on chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin estuary, p. 88-102. In: R. D. Cross and D. L. Williams (eds.). Proceedings of the National Symposium on Freshwater Inflow to Estuaries. U. S. Fish Wildlife Service. Biological Services Program. RWS ?OBS-81/04.

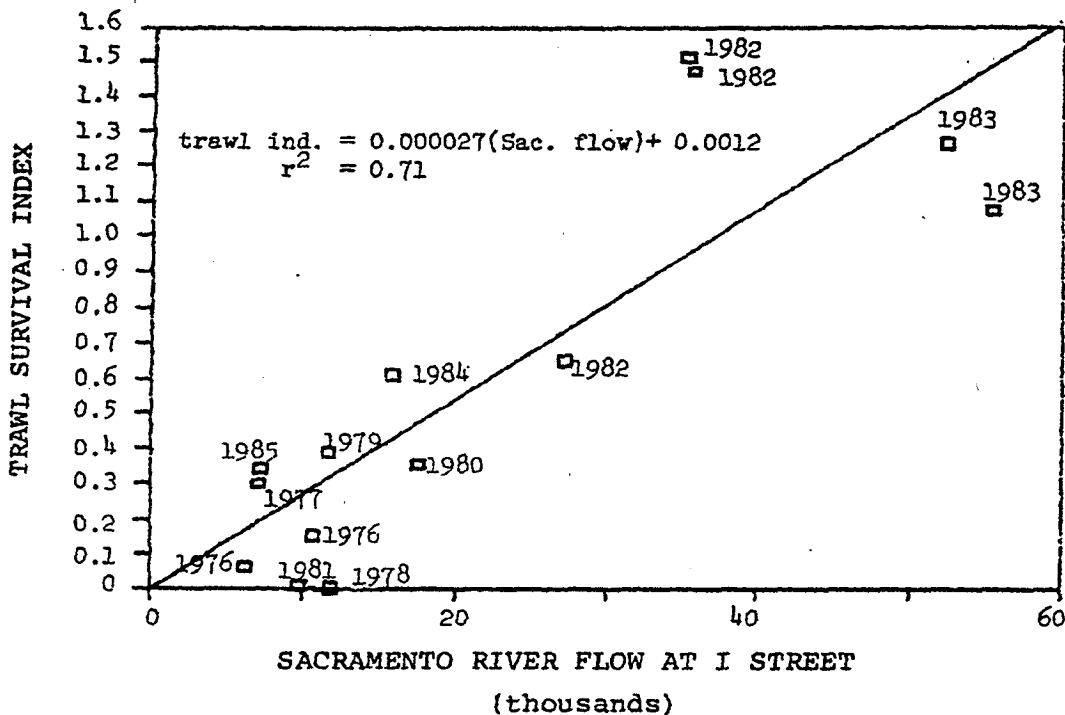


Figure II-2. Relationship between trawl survival index of late May and June plants of chinook salmon and flow in the Sacramento River at I Street. Survival index based on trawl catches near Chipps Island (Stevens et al. 1985).

Resource Category: Fisheries - Chinook Salmon

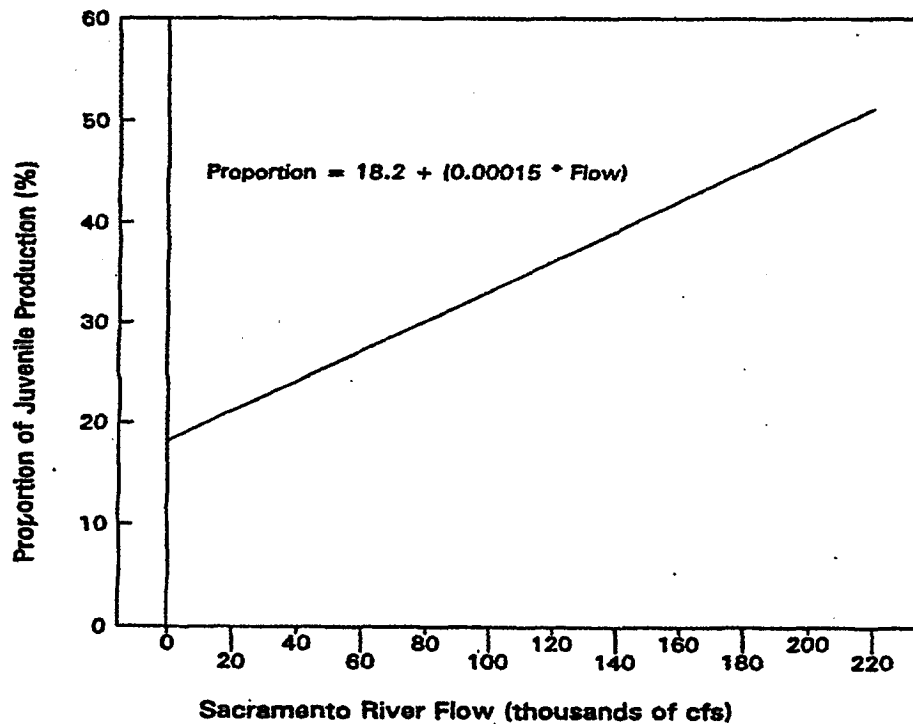
Relationship: Proportion of young salmon that move to the Delta as fry as a function of Sacramento River flow.

Description: Young salmon move to the Delta to rear in increasing numbers when flows are sufficient to provide transport to the Delta

Assumptions: Catch in seine surveys are representative of the distribution of salmon fry in the Delta and Sacramento River.

Basis: Salmon migrate to the Delta when flows are high to minimize predation and possibly due to declining rearing habitat in rivers (flows are too high).

Reference: U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.



SOURCES: Hinkle (1982) and U.S. Geological Survey (1982).

**AVERAGE MONTHLY SACRAMENTO FLOW TO THE DELTA VERSUS
PROPORTION OF JUVENILE PRODUCTION MOVING DOWNSTREAM**

Resource Category: Fisheries - Chinook Salmon

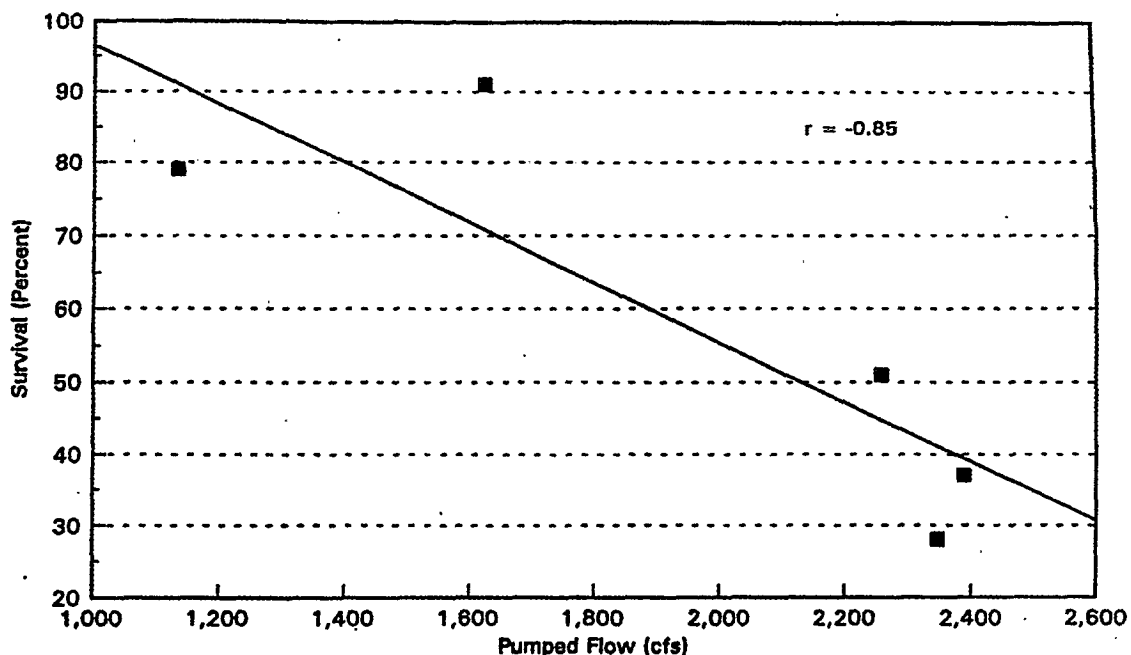
Relationship: Proportion of young salmon that survive passage through the GCID intake canal as a function of diversion rate at the GCID diversion.

Description: Young salmon are lost at the GCID intake screens or from predation in front of the screens as a function of diversion rates in the canal.

Assumptions: Survival or successful passage through the canal and avoidance of the diversion intake screen is related to diversion rates alone (Is river flow also a factor?).

Basis: A portion of the downstream migrant salmon on the Sacramento River migrate through the GCID diversion channel and their successful passage past the diversion screens appears to be related to the diversion rate at the GCID diversion mid-way down the channel.

Reference: U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.



SOURCE: Cramer et al. (1990).

**ESTIMATED CHINOOK SALMON SURVIVAL RATE THROUGH GLENN-COLUSA
IRRIGATION DISTRICT DIVERSION CHANNEL VERSUS FLOW PUMPED**

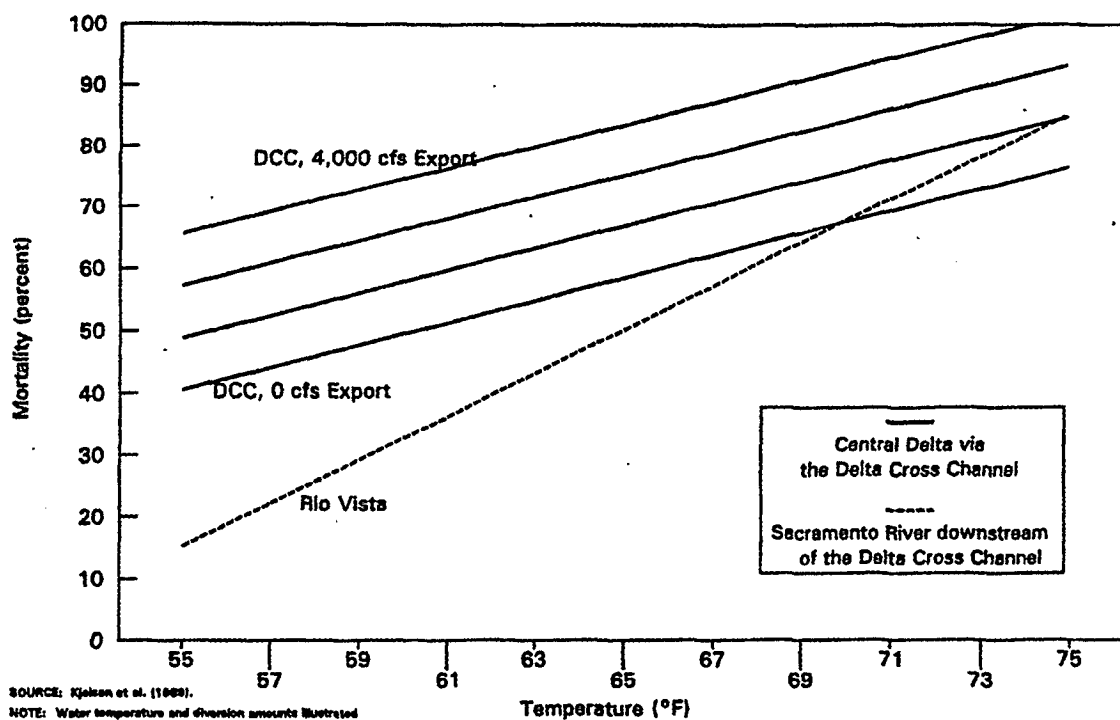
Resource Category: Fisheries - Chinook Salmon

Description: Young salmon moving to the Delta are lost into the Central Delta where they are subject to poorer habitat, greater export potential, and greater numbers of predators.

Assumptions: Model assumes mortality is directly related to flow through Delta Cross Channel and export rates..

Basis: Salmon migrate to the Delta have the potential to move through the Delta Cross Channel into the Central Delta where the risk to mortality from various causes is higher.

Reference: CVPIA PEIS

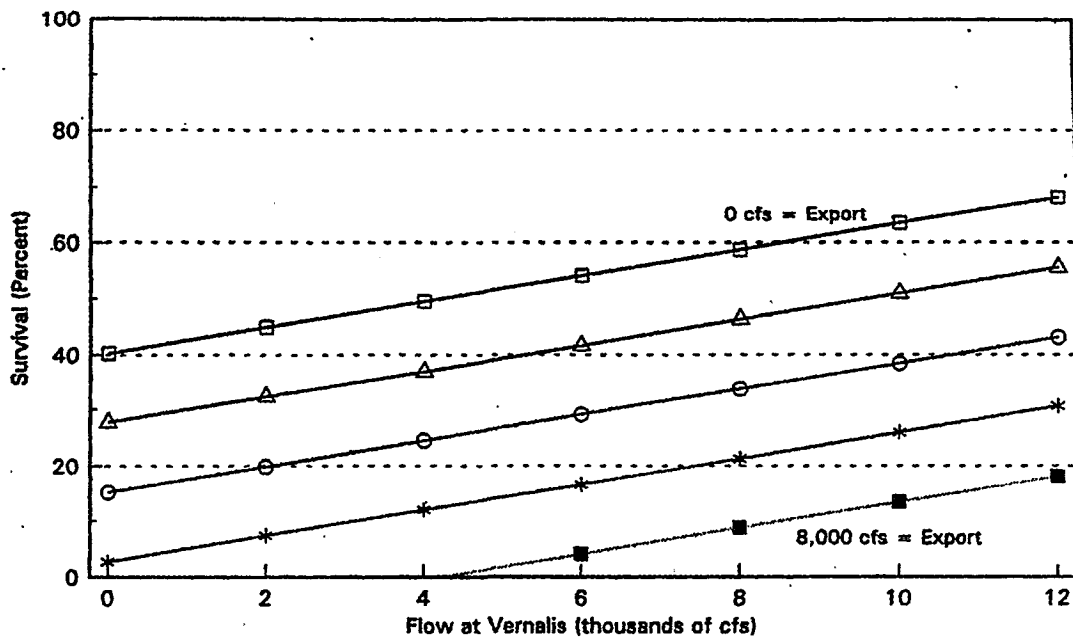


PREDICTED SACRAMENTO RIVER CHINOOK SALMON SMOLT MORTALITY FOR TWO DELT MIGRATION PATHWAYS VERSUS SACRAMENTO RIVER WATER TEMPERATURE

Resource Category: Fisheries - fall run chinook salmon

Relationship: Survival of San Joaquin smolts as a function of Vernalis flow and export rates.

Reference: U.S. Fish and Wildlife Service. 1995. Working paper on restoration needs: actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA.



SOURCE: Hargreaves (1993).

**PREDICTED SAN JOAQUIN RIVER CHINOOK SALMON SMOLT SURVIVAL
VERSUS FLOW AT VERNALIS AND COMBINED CENTRAL VALLEY
PROJECT/STATE WATER PROJECT EXPORTS**